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RESOURCE STATUS AND ASSESSMENT BRANCH

Census of Swift Fox (*Vulpes velox*) in Canada and Northern Montana: 2000-2001

Alberta Species at Risk Report No. 24

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Census of Swift Fox (*Vulpes velox*) in Canada and Northern Montana: 2000-2001

A. Moehrenschlager and C. Moehrenschlager

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EXECUTIVE SUMMARY

The swift fox (*Vulpes velox*) is a rare, house-cat-sized carnivore that can race across native prairie at speeds of up to 60 km/hr. Although swift foxes were once so abundant in Canada that 117 025 were trapped between 1853 and 1877, this species was extirpated from Canada and northern Montana by the late 1930s. Since 1983, a reintroduction program has been underway to restore this species to Canada and the most recent releases were made in Grasslands National Park, Saskatchewan in 1997.

A Canadian swift fox census during the winter of 1996-1997 revealed that the reintroduced population was located within two regions: 1) approximately 192 foxes were estimated to span the Alberta/Saskatchewan border south of the Cypress Hills; and 2) approximately 89 foxes were thought to exist along the United States border in and around Grasslands National Park, Saskatchewan. Concurrent with the Canadian swift fox reintroduction program, mounting evidence suggested that Canadian fox releases had also established a small swift fox population in north-central Montana. However, a coordinated international effort has not been previously conducted to assess the extent and composition of the shared swift fox population in Canada and Montana.

The focus of the 2000-2001 census was: 1) to estimate changes in the distribution and abundance of swift foxes within Canada since the 1996-1997 census; 2) to estimate the distribution and abundance of swift foxes in adjacent areas of Montana.

The 1996-1997 census area of 108 Canadian townships was resurveyed and supplemented with 80 Montana townships to form a total study area of 17 326.1 km^2. Following training at the Calgary Zoo, six field teams conducted catch-and-release surveys in 80.3% of the study area townships from November 4, 2000 until February 15, 2001. Significant results were as follows:

1. In total, 149 swift foxes were live-trapped: 97 in the Alberta/Saskatchewan border area population, 14 in the Grasslands National Park region, and 38 in adjacent Montana areas. By comparison, 32 swift foxes were caught during catch-and-release efforts during the Canadian 1996-1997 swift fox census. In 2000-2001, 98.6% of captured foxes were unmarked, which means that they were wild-born in the Canadian/Montana population. This is a greater proportion of wild-born foxes than that recorded in 1996-1997, when 81.3% were unmarked.
2. The known distribution of swift foxes in Canada and Montana has substantially increased through the results of this census. In the Alberta/Saskatchewan border area swift foxes were found in 18 townships in 1996-1997 and during the 2000-2001 census they were found in 38 townships. In the Grasslands National Park region, swift foxes were found in 7 townships during the previous census, whereas they have now been located in 13 townships. In Montana, where a previous census of this kind had not been conducted, swift foxes were found in 25 townships. Hence, the 1996-1997 census found swift foxes in 25 townships

whereas the current survey yielded evidence of swift foxes in 76 townships; this represents a three-fold increase in the known swift fox distribution.

3. The number of swift fox captures in Canada has tripled since 1996-1997, in areas that were previously surveyed at the same time of year. Similar recapture rates between the 2000-2001 census and the 1996-1997 census indicate that the three-fold increase of the Canadian swift fox population in replicated areas is not due to higher trapability of foxes during this census but, in fact, that this represents a statistically significant, three-fold increase in the fox population in these areas.
4. Fox body condition and age ratios are similar to those of the 1996-1997 census, but there has been a significant shift from a male-biased sex ratio previously to a female-biased population during this census.
5. The increase in swift fox population size since 1996-1997 differed significantly between the Canadian swift fox subpopulations. Captures in the replicated regions of the Alberta/Saskatchewan border subpopulation have significantly increased by a factor of 3.5. By comparison, the 1.6-fold increase in the Grasslands National Park region is not statistically significant.
6. In newly surveyed areas, 50% of 16 townships in the Alberta/Saskatchewan border area had successful captures for a total of 22 foxes. By comparison, only 9% of 11 newly surveyed townships in the Grasslands National Park area had successful captures totalling one fox. In Montana, which had not been previously surveyed, 31.8% of the 66 townships had swift foxes totalling captures of 38 individuals.
7. Capture success for replicated and new areas combined was highest in the Alberta/Saskatchewan border area with 1 new capture every 10.0 trapnights, intermediate in Montana with 1 new capture/33.2 trapnights, and lowest for the Grasslands National Park region with 1 new capture/38.6 trapnights.
8. Application of the same population estimation technique utilized in 1996-1997 suggests that the Alberta/Saskatchewan border population consists of 560 individuals (compared to 192 previously), the Grasslands National Park area contains 96 individuals (compared to 87 previously), and the sampled Montana area contains 221 foxes. This suggests a total population size of 877 foxes.
9. Previously the Canadian swift fox population has been thought to consist of two isolated subpopulations. The comparative results in Canada suggest that this population has experienced a significant increase since 1996-1997. Furthermore, the present census suggests that the foxes in Canada and Montana now form one loosely-connected population.

1.0 INTRODUCTION

1.1 Historical Distribution and Abundance

Swift foxes historically ranged from Canada, to eastern Wyoming, the Dakotas, Nebraska, Kansas and Colorado through to north-western Texas, the Oklahoma panhandle, and eastern New Mexico (Scott-Brown et al. 1987). Naturalists and explorers considered swift foxes abundant within their historical range, and 10 614 swift fox pelts were traded by the American Fur Company at the Missouri and Sioux outfits between 1835 and 1838 (Hillman and Sharps 1978) while only 1989 red fox and 108 gray fox furs were traded during the same period (FaunaWest Wildlife Consultants 1991). Swift fox pelts had little value compared to those of other furbearers, selling for $0.25 in Kansas by 1861 (FaunaWest Wildlife Consultants 1991) and for between $0.30 and $1.32 in London in 1906 (Seton 1925); consequently, swift foxes were probably captured incidentally as trappers targeted more lucrative furbearers.

Before European settlers arrived, swift foxes were found in Canada from the Pembina Hills in Manitoba across southern Saskatchewan to the southern foothills of the Rocky Mountains in Alberta (Carlington 1980). An average of 4876 pelts was sold in Canada by the Hudson Bay Company annually between 1853 and 1877 for a total of 117 025 specimens (Rand 1948) and the species was rare in the northern portions of its range by 1900 (Hillman and Sharps 1978). Between 1922 and 1925, an average of only 508 swift fox pelts were taken in Canada and record-keeping discontinued in 1925 because of these low numbers (Carlington 1980). The last Canadian museum specimen was collected in 1928 near Govenlock, Saskatchewan and the last sighting was made near Manyberries, Alberta in 1938 (Soper 1964). The species was officially designated as extirpated from Canada in 1978 (COSEWIC 2001). Today, swift foxes only exist in approximately 40% of their historical North American range (Kahn et al. 1997).

1.2 Canadian Swift Fox Reintroduction

In 1973 two swift fox pairs from Colorado were sent to the home of the Smeeton family near Cochrane, Alberta (Herrero et al. 1991) where both pairs bred in 1974 (Herrero et al. 1986). In 1976, Dr. Steve Herrero of the University of Calgary and the Smeetons agreed to assess the feasibility of reintroducing swift foxes to Canada. The political and biological aspects of this potential reintroduction were consequently investigated with the assistance of three University of Calgary graduate students (Carlington 1980, Reynolds 1983, Schroeder 1985). In 1983, the first releases of captive-bred foxes were attempted in Alberta (Reynolds 1983) followed by releases in Saskatchewan in 1984, and agreements subsequently signed between federal and provincial governments to delineate responsibilities for further swift fox reintroductions (Pruss 1994).

Swift foxes were released annually from 1983 until 1997. A feasibility study was completed in 1993 which concluded that, based on previous successes, a self-sustaining population of swift foxes could be established and that the most effective method of

achieving this goal would be to conduct and monitor 3 to 5 more years of swift fox releases (Brechtel et al. 1993, Carbyn et al. 1994). Swift fox reintroductions occurred from 1983-1996 in the Alberta/Saskatchewan border area and from 1984-1997 in the Grasslands National Park region of south-central Saskatchewan. An attempted reintroduction into the Milk River ridge region in southern Alberta was discontinued because of a rabies outbreak in the skunk population. In total 942 foxes were released through captive-breeding and, more recently, translocation from the United States. As a result of Canadian reintroductions, the number of swift fox reports in north-central Montana have steadily increased, and Zimmerman (1998) established that swift foxes were establishing territories and breeding successfully in northern counties of the State.

Reintroductions of swift foxes have also occurred on the Blackfoot Indian Reserve in Montana, and have been ongoing since 1998 through the collaboration of the Blackfoot Nation, Defenders of Wildlife, the Cochrane Ecological Institute, and Montana Fish, Wildlife, and Parks. Currently, foxes from these reintroductions are thought to be isolated from the swift fox population in Canada and north-central Montana.

1.3 Population Status (1994-1999)

The ecology, status, and threats of Canadian swift foxes were intensively studied from 1994 until 1998. During this time, 76 swift foxes and 11 coyotes were radio-tracked for up to 3.5 years. Methods of reducing swift fox injuries were developed, factors influencing swift fox survival and reproduction were identified, the efficacy of swift fox translocations was evaluated, the effects of pipeline construction on swift foxes were determined, and factors reducing coyote predation on swift or kit foxes throughout North America were identified (Moehrenschlager 2000). These investigations also showed that, although survival and reproductive rates were variable between years, the swift fox population can sustain short-term fluctuations in predator pressure and climatic extremes.

As one part of the ongoing recovery program, a national swift fox census was conducted in Alberta and Saskatchewan during the winter of 1996-1997 to determine the composition, distribution, and abundance of Canada's swift fox population. The population is split into two subpopulations; the first, which spans the Alberta / Saskatchewan border, was estimated to have 192 foxes while the second, which is centred around Grasslands National Park in south-central Saskatchewan was estimated to contain 89 foxes (Cotterill 1997). Moreover, census results combined with ongoing live-captures for the 3.5 year-long research study (Moehrenschlager 2000), showed that 88% of individuals trapped from 1995 – 1998 were born in the wild in Canada. Hence, the Canadian swift fox population no longer relied on the reintroduced founder stock. In 1999, the Alberta / Saskatchewan border population assessment (Moehrenschlager and Moehrenschlager 1999) showed that this subpopulation was stable or increasing in size.

1.4 Census Objectives (2000-2001)

The primary goal of the National Recovery Plan for the Swift Fox is to restore populations to self-sustaining levels in the Canadian prairies by the year 2000 (Brechtel et al. 1996), and to remove swift fox from the endangered species list. Since Canadian swift fox releases ended in the Alberta/Saskatchewan border area before the 1996-1997 swift fox census, one can now ascertain whether the foxes can persist for a four-year time span without population supplementation. The Grasslands subpopulation did have releases in 1997 but the lack of releases in subsequent years still allows an examination of the state of this subpopulation without annual releases. Consequently, the Canadian Swift Fox Recovery Team and Montana Fish, Wildlife and Parks identified the following objectives for this international census:

Key Objectives

1. To estimate changes in the distribution and abundance of swift foxes within the Canadian area surveyed during the 1996-1997 census.
2. To estimate the distribution and abundance of swift foxes in Montana, south of the Canadian Grasslands National Park and Alberta/Saskatchewan subpopulations.

The census results will also be utilized to investigate secondary Canadian National Recovery Team objectives, which focus on environmental and demographic factors that determine the potential growth or extinction of the reintroduced population:

1. To determine exposure of swift foxes to disease in Canada. This is conducted through the collaboration of the Calgary Zoo and the Wildlife Trust.
2. To conduct preliminary swift fox habitat comparisons between sites with captures vs. those sites that did not have captures. The Calgary Zoo is partnering with Parks Canada and Alberta Sustainable Resource Development - Fish and Wildlife Division in this endeavour.
3. To determine the genetic relatedness and connectivity between separate regions of the Canadian and Montana swift fox population. The Calgary Zoo is partnering with the University of Alberta on this question.
4. To develop a population viability analysis which will model the likelihood of swift fox population sustainability for the Canadian/Montana swift fox population that was surveyed during the census. The Calgary Zoo will partner with Oxford University and additional collaborators to address this issue.

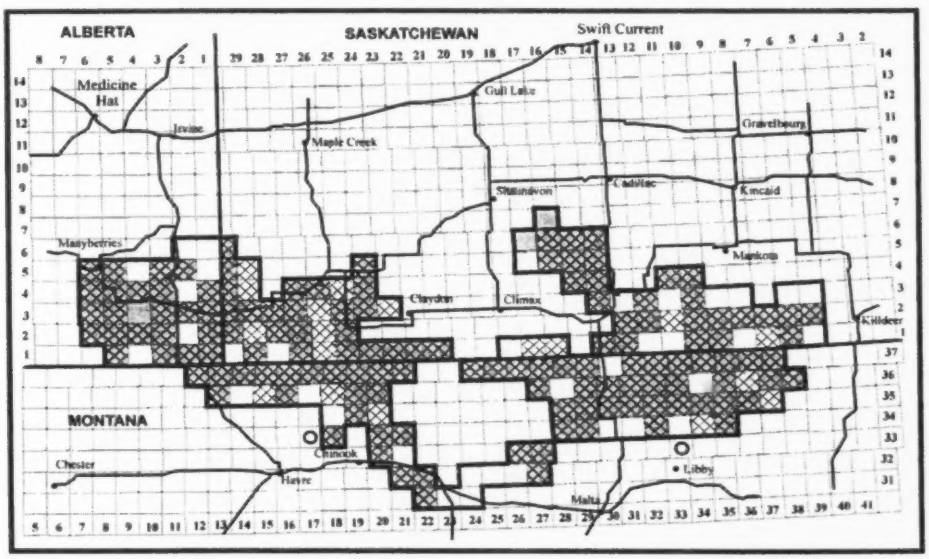
Research is ongoing regarding these four secondary objectives, but the focus of this report is to address the two key objectives. This analysis is intended to be a timely follow-up to field work conducted from November 2000–February 2001. As such, population size analyses are preliminary and will be subject to further review over the course of the next year.

2.0 METHODS

2.1 Study Area

The study area spanned the borders of Alberta, Saskatchewan and Montana (48°25'N; 49°29'N; 106°35'W; 110°48'W), an area with scarce human habitation that is primarily used for cattle ranching. The Alberta/Saskatchewan border area spanned from Manyberries, Alberta to Claydon, Saskatchewan (Map 1, Map 3). The Grasslands National Park region spanned from Climax in the west to Killdeer in the east (Map 1, Map 4). The Montana study area spanned from Wild Horse in the west to Opheim in the east (Map 1, Map 5).

This area is within the Brown Soil Zone characterized by shallow profiles, low amounts of organic matter, nitrogen and phosphorus, and a compact calcium carbonate layer averaging about 30 cm below the surface. While a small proportion of crop-land (<5%) is present on the periphery of the study area, the main vegetation types are representative of the Mixed Prairie Association which is characterized by an abundance of mid- and short-grasses, numerous forbs, and few scrubs (Smoliak 1985).



Map 1
Suspected range/sampled range for Canada and Montana in 2000-2001.

Legend

- Suspected range
- Randomly selected townships
- Surveyed townships
- Additional townships surveyed

2.2 Training

Training of field staff was conducted at two sites. Five crews were at the Calgary Zoo from October 30–November 3 inclusively where they were instructed in fox handling

procedures, landowner relations, safety, GPS use, mapping, data collection, snow-tracking evaluations, and reporting requirements. In addition, a swift fox was handled by the field crews at the Calgary Zoo.

From November 4 until November 9, all trapping crews moved to Consul, Saskatchewan. During this time period, traps were lined with hard-board to reduce injuries, equipment was assembled, and field training was conducted.

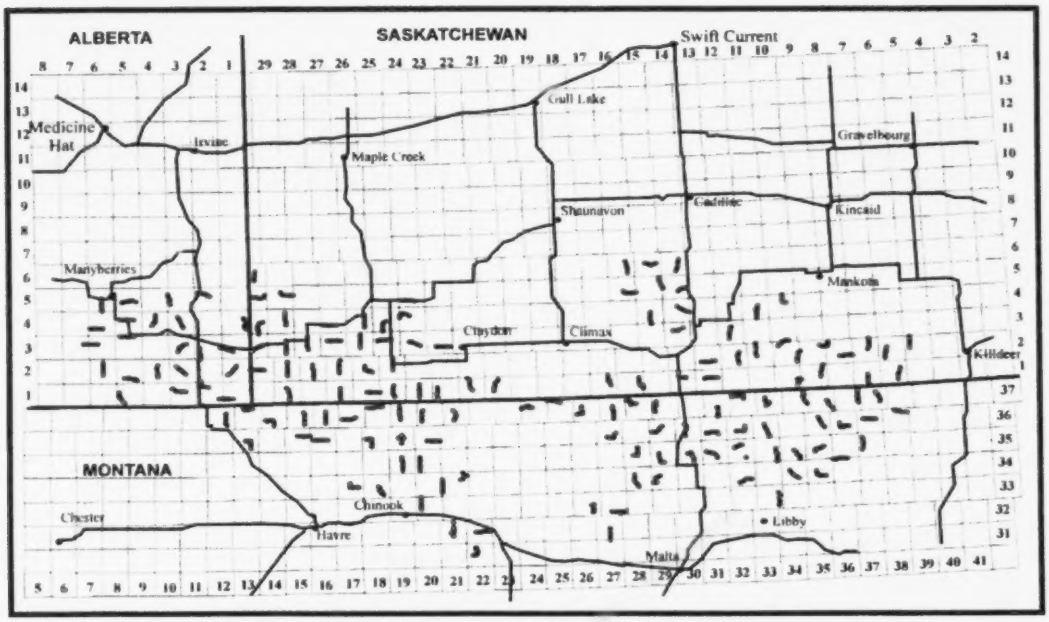
During training, 18 foxes were trapped in 3.5 nights on three townships and all recaptured foxes were handled to maximize training opportunities; thereafter recaptured foxes were not handled. Subsequently, teams split into respective jurisdictions. Swift fox trapping was conducted by ten field staff, the team coordinator (CM), the census coordinator (AM), and two veterinarians from the Wildlife Trust. Field staff formed five teams, and of these, two surveyed the Alberta/Saskatchewan border subpopulation, one surveyed the Grasslands National Park region, and two sampled the Montana areas. The sixth team, which consisted of AM and the Wildlife Trust veterinarians, sampled swift foxes in the core of the Alberta/Saskatchewan border population in January 2001. To enhance Conservation Medicine components, serological health assessments were conducted of captured swift foxes at this time but a discussion of these findings is beyond the scope of this report.

2.3 Catch-and-Release Trapping

The Canadian swift fox census area was determined by the National Swift Fox Recovery Team in 1996 based on habitat criteria and background information (Cotterill 1997). The suspected swift fox range consisted of 65 townships in the Alberta/Saskatchewan border region and 43 townships in and around Grasslands National Park in south-central Saskatchewan. Of these 108 townships, 81 (75%) were randomly selected for subsequent sampling, of which 2 were excluded at the request of the resident landowners. Similarly a census area of 80 townships was selected by Montana Fish, Wildlife and Parks staff in 2000, and 75% of these townships were selected for subsequent sampling (Map 1). Montana wildlife officials and the Canadian Swift Fox Recovery Team agreed not to include recent reintroduction areas on the Blackfoot Indian Reserve in north-western Montana, which may be disconnected from the current continuous Canada/Montana swift fox population. During the 1996-1997 census, live-trapping in 58 of the 81 randomly selected, Canadian townships was successfully completed. Catch-and-release trapping priorities for the 2000-2001 census, with diminishing priority, were as follows: 1) replicate townships trapped in 1996-1997; 2) sample the remaining 75% of randomly selected townships in Canada and Montana; and 3) survey the final 25% of townships. Although trap effort significantly increased from the previous census, not all townships could be surveyed due to access, time, or equipment restrictions.

Swift fox trapping was conducted from November 4, 2000 until February 15, 2001 in Alberta, Saskatchewan, and Montana. Individual live-traps were placed at one-kilometre intervals along a five kilometre continuous section of the trail closest to the center of respective townships. The inter-trap distance was adjusted by up to 100 m to allow trap

placement along fences or on top of hills (Map 2). Each township was surveyed with six traps for three nights, for a total of 18 trap nights per township. Catch-and-release trapping was conducted on consecutive nights when possible, but this was dependent on weather conditions.



Map 2
Trap locations for Canada and Montana in 2000-2001.

Legend

- Trap Location

Two sizes of fox live-traps were used for catch-and-release procedures; they were 109 cm x 39 cm x 39 cm Tomahawk (Tomahawk Live Trap Co., Tomahawk, WI) double-door or 83 cm x 31cm x 31 cm Tomahawk single door box traps. Trap bottoms and corners were lined with 3 mm hard-board to reduce the likelihood of jaw, canine, or paw injuries (Moehrenschlager 2000). Catch-and-release trapping was conducted at night to reflect fox activity periods, to avoid heat-stress, and to prevent fox disturbance by people. Traps were generally set between 1800 and 2000, checked between 2400 and 0200, and closed following a second check between 0600 and 0800. Trapping was not conducted at temperatures colder than –20°C or when snow, rain, and wind conditions were potentially hazardous to captured foxes (Table 1).

Foxes were handled by two field workers in each team. The first positioned the animal on his/her lap to shelter it from the wind, one hand restrained the head and covered the eyes, and the second hand restrained the body. The second field worker sexed and aged the fox, conducted parasite counts, scored body condition through palpation on an index ranging from 1 (poor) to 5 (excellent), collected a hair sample for genetic analyses, checked for injuries, and tattooed the ear for identification. Foxes were uniquely marked with tattoo dye so that recaptured individuals could be easily identified.

Table 1. Weather criteria protocols for live-trapping swift foxes.

Weather Conditions	Trap Setting Temperature (°C)	Trap Closing Temperature (°C)
No Wind or Snow	≥ - 17	≤ - 20
Low Wind	≥ - 17	≤ - 20
Moderate Wind	≥ - 15	≤ - 18
Strong Wind	≥ - 13	≤ - 16
Low Wind and Light Snow	≥ - 12	≤ - 15
Moderate or High Wind and Moderate, Heavy or Blowing Snow	Traps not set	---
Rain	Traps not set	---

Age classifications were based on the size, colour, and wear of teeth (see Ralls et al. 1990). Swift foxes emerge at approximately three weeks of age and emergence dates in the Canadian swift fox population range from May 25–June 9 (Pruss 1994, Moehrenschlager 2000). Given the variation in parturition dates and the extent of the census trapping period, captured juveniles were likely 5.5–10 months old. Accordingly, adults were 17.5 months or older.

2.4 Supplementary Indicators of Swift Fox Presence: Snow-tracking, Spot-lighting and Incidental Sightings

Snow-tracking has been used as an indicator of swift fox presence in Canada (Mamo 1994, Moehrenschlager and Moehrenschlager 1999), and in this census, snow-tracking was conducted to supplement trapping information on the distribution of Canadian swift foxes. Within surveyed townships, each accessible trail was searched for the tracks of swift foxes, other carnivores and lagomorphs. No time restrictions were imposed for searches and trackers travelled by truck, ATV or on foot. The choice of townships was influenced by snow conditions but the emphasis with decreasing priority was on townships that had not been trapped, townships that had been trapped but where no captures had been made, and townships where swift foxes had been captured.

Spot-lighting has been used to locate swift foxes (Mamo 1994, Moehrenschlager 1994, Moehrenschlager and Moehrenschlager 1999) in Canada. While it may not accurately reflect changes in population abundance, it is useful for presence/absence surveys. During this census, spot-lighting was conducted to find swift foxes in areas where they were not know to exist or to visually confirm their presence in areas where snow-tracking or scat sign had been found.

The priorities for spot-lighting were: 1) to survey townships that had swift fox sign during snow-tracking but where no captures had been made; 2) to spotlight townships where neither snow-tracking nor trapping were conducted; 3) to survey townships where foxes had been trapped. For priorities 1 and 2, all accessible trails were sampled up to

three times with at least two hours between spot-lighting passes. For priority 3 areas, trails were only sampled once.

To conduct spot-lighting, two field workers drove no faster than 40 km/hr while scanning both sides of the road with a one-million candlelight spotlight. Carnivores were identified by eye or using binoculars, while jackrabbits or cottontails were counted on all surveyed trails. Incidental sightings were made opportunistically at times that spot-lighting was not conducted. Locations of swift foxes, red foxes, and coyotes obtained through the various survey techniques were recorded with a GPS.

2.5 Data Analyses

The number of sampled townships was compared relative to the survey area size of the Alberta/Saskatchewan border, the Grasslands National Park area, and Montana survey areas. The proportion of wild-born individuals in the population was compared between the 2000-2001 and the 1996-1997 censuses. Body weights were compared between the censuses with unpaired t-tests for juvenile and adult foxes respectively. Moreover, body weights were compared between the Alberta/Saskatchewan border, Grasslands National Park, and the Montana regions using a General Linear Model that also incorporated fox age. These tests, in combination with a Mann-Whitney U test that compared body assessment scores between the censuses, were conducted to determine if the condition of trapped foxes had changed over time. Age ratio differences between the present census and former census, and sex ratio comparisons, over time and between areas, were tested using chi-square.

The number of captures on replicated Canadian townships was compared between 2000-2001 and 1996-1997 using Wilcoxon paired rank tests individually for the Canadian subpopulations and the combined population. The change in capture numbers on replicated townships was compared between the subpopulations with a Mann-Whitney U test. Two townships in the Alberta/Saskatchewan border population were excluded from paired analyses because they were only trapped for 0.5 nights during 2000-2001 presently compared to 3.0 nights during the previous census. Two foxes were trapped in these townships during the half-night in 2000-2001.

Trapping success was compared between the Alberta/Saskatchewan border, Grasslands National Park, and the Montana regions by comparing the number of trapnights/new capture. For the Canadian areas, this measure was also compared between the 2000-2001 and the 1996-1997 censuses. Swift fox trapability was also compared between the two censuses by examining the proportion of captured foxes that was subsequently recaptured (for background, see Moehrenschlager and Moehrenschlager 1999). To allow for standardized comparisons over time, subpopulation and total population fox densities as well as respective abundance estimates were derived for the Canadian and Montana areas using the methods outlined in Cotterill (1997). Data collected in Alberta during the census were entered into the Biodiversity/Species Observation Database (BSOD). Initial capture locations of swift foxes were mapped for the Alberta/Saskatchewan border area, the Grasslands National Park region, and Montana; recaptures were not mapped.

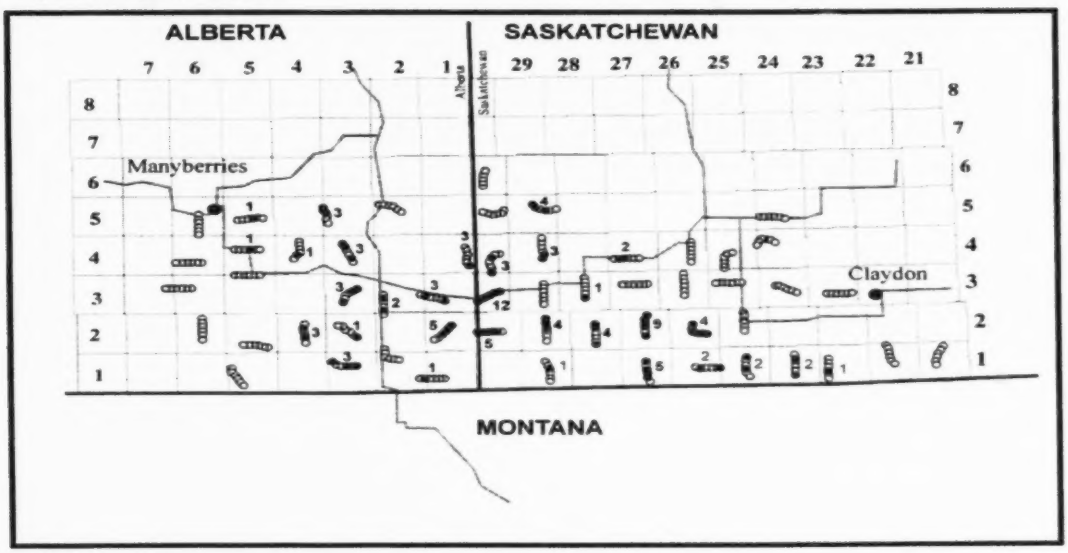
Moreover, swift fox locations obtained through spot-lighting, sign-tracking, or incidental sightings were mapped for all regions.

3.0 RESULTS

3.1 Catch-and-Release Trapping Effort

The census area consisted of three connected regions: 1) Alberta/Saskatchewan border: 65 townships – 5990.4 km^2; 2) Grasslands National Park region: 43 townships – 3962.9 km^2; 3) Montana: 80 townships - 7372.8 km^2. The total census area spanned 17 326.1 km^2 (Map 1).

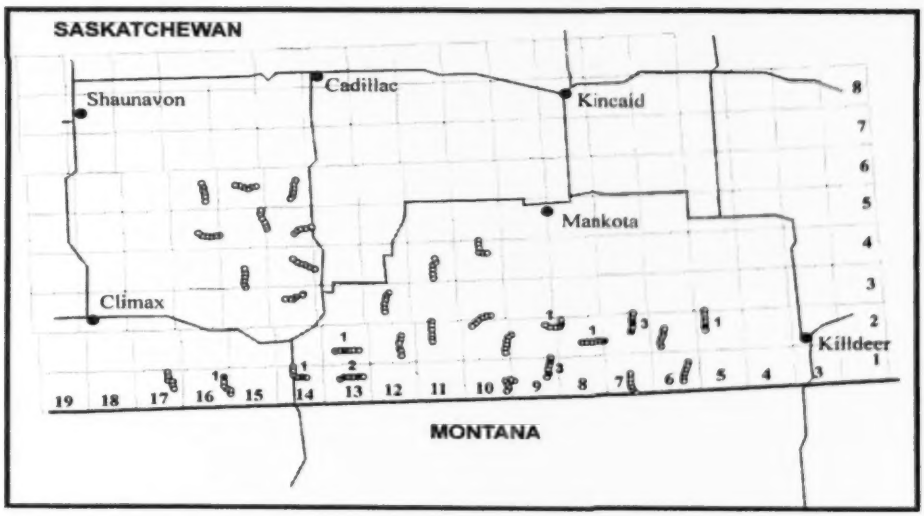
Swift fox trapping was conducted in 151 (80.3%) of the 188 study area townships. In the Alberta/Saskatchewan border area, 84.6% (55/65) of townships were surveyed during 969 trapnights (Map 1, Map 3) and, in the Grasslands National Park area, 69.8% (30/43) of townships were surveyed in 540 trapnights (Map 1, Map 4). In 1996-1997, 75% of the townships within the Canadian sample area were randomly selected; 95.9% (47/49) of the randomly selected Alberta/Saskatchewan border area townships were trapped and 93.3% (28/30) of randomly selected Grasslands National Park region townships were surveyed during the current census (Map 1). With the greater trapping effort during the 2000-2001 census, 23% more townships were sampled in Canada than during the 1996-1997 census. All 58 townships that were sampled in Canada previously were re-trapped; ie. 39 in the Alberta/Saskatchewan border area and 19 in the Grasslands National Park region (Map 3, Map 4). In Montana 82.5% (66/80) of study area townships were sampled in 1188 trap nights (Map 1, Map 5).



Map 3
Alberta and Alberta/Saskatchewan border area locations of swift fox captures in 2000-2001.

Legend

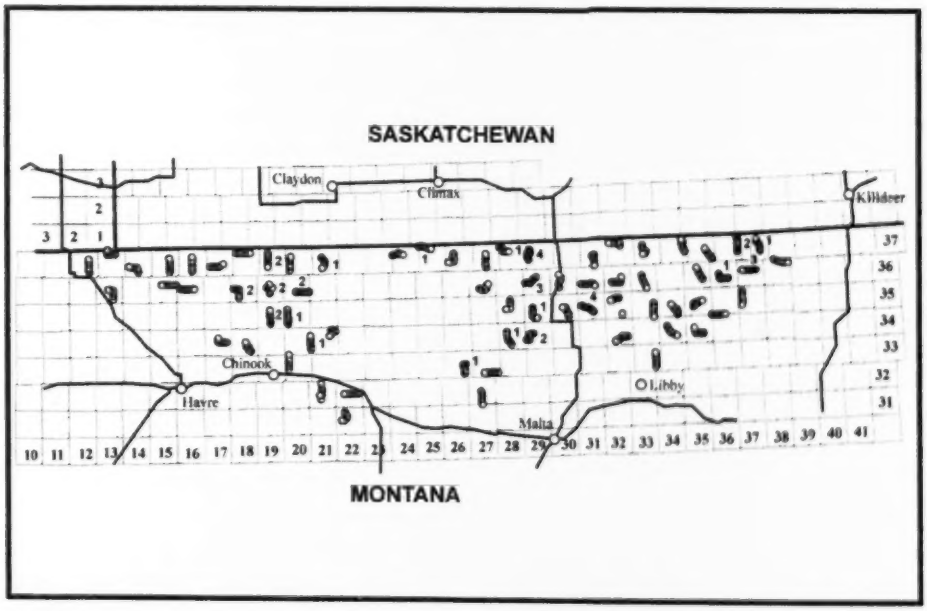
- o Trap location
- ● Swift fox captured in trap
- 1 Total swift fox captures on a trap line



Map 4
Grasslands National Park locations of swift fox captures in 2000-2001.

Legend

- o Trap location
- ● Swift fox captured in trap
- 1 Total swift fox captures on a trap line



Map 5
Montana locations of swift fox captures in 2000-2001.

Legend

- o Trap location
- ● Swift fox captured in trap
- 1 Total swift fox captures on a trap line

3.2 Population Composition

In total, 149 swift foxes were captured; 97 in the Alberta/Saskatchewan border area, 14 in Grasslands, and 38 in Montana (Table 2). In 1996-1997, 81.3% (26/32) of captured foxes were wild-born while 12.5% were captive-bred and 6.3% were translocated foxes from Wyoming. Compared to the 1996-1997 census, the proportion of wild-born foxes has increased. Of 142 foxes with known origin, 98.6% were wild-born while one capture each of a captive-bred and a translocated fox, constituted the remaining 1.4% (Table 2).

Table 2. Age, sex, and origin of swift foxes trapped in 1996-1997 and 2000-2001.

Area Sampled	# of Foxes	Age*		Sex*		Origin*		
		Adult	*Juvenile*	*Male*	*Female*	*Wild-born*	*Captive-bred*	*Trans-located*
AB/Sask. 1996-1997	24	13	11	13	11	20	2	2
Grasslands 1996-1997	8	3	5	7	1	6	2	0
Total 1996-1997	32	16	16	20	12	26	4	2
AB/Sask. 2000-2001	97	55	39	39	56	91	1	1
Grasslands 2001-2002	14	9	4	7	6	13	0	0
Montana 2001-2002	38	17	20	16	21	36	0	0
Total 2000-2001	149	81	63	62	83	140	1	1

* In 2000/2001, the age, sex, and origin of one escaped fox in each of the Border, Grasslands, and Montana areas was unknown. In addition, the sex and age of one fox, the age of a second fox, and the origin of two foxes in the border area is unknown. Moreover, one fox in the border area and one in Montana were either wild-born in Canada or translocated from Wyoming.

Body weights were similar between this and the previous census for adults (1996-1997: 2.3 ± 0.2 kg; 2000-2001: 2.3 ± 0.2 kg; $t = 0.60$, $df = 95$, $p = 0.55$) and juveniles (1996-1997: 2.1 ± 0.2; 2000-2001: 2.2 ± 0.2; $t = 0.71$, $df = 77$, $p = 0.48$). Similarly, body condition scores were similar between the censuses ($z = 1.8$, $n_1 = 32$, $n_2 = 143$, $p = 0.07$). Moreover, once the significant age effect was accounted for in a general linear model ($F_{1, 144} = 13.0$; $p < 0.0001$), there was no significant difference in fox body weights between the Alberta/Saskatchewan border population, the Grasslands area, and Montana ($F_{2, 144} = 1.7$; $p = 0.19$).

The age ratio in Canada is similar now to that recorded during the previous census (1996-1997: 50% adults, 2000-2001: 56% adults; $x^2 = 1.0$, $df = 1$, $p = 0.32$). However, the sex ratio has changed significantly from a male bias (63% males) in the 1996-1991 census to a female bias (57% females) during the 2000-2001 survey ($x^2 = 3.9$, $df = 1$, $p < 0.05$; Table 2). There was no difference in the sex ratio between the Alberta/Saskatchewan, Grasslands, and Montana sampling regions during the present census ($x^2 = 0.8$, $df = 2$, $p = 0.68$).

3.3 Catch-and-Release Trapping Success and Population Changes

In 2000-2001 significantly more foxes were captured in Canada on the townships that were originally sampled in 1996-1997 (Wilcoxon paired rank: $z = 4.0$; $n = 56$; $p < 0.0001$). While 29 were captured in these areas previously, 86 were caught during the present census; this represents a three-fold increase.

The increase was primarily due to higher capture rates in the Alberta/Saskatchewan border population. Here the number of captures increased significantly (Wilcoxon paired rank: $z = 3.7$; $n = 37$; $p < 0.0001$) from 21 to 73, a 3.5-fold increase. Although the number of captures also increased in the Grasslands area from 8 to 13, this 1.6-fold increase was not statistically significant (Wilcoxon paired rank: $z = 1.3$; $n = 19$; $p = 0.19$). In fact, the change in the number of captures on replicated townships was significantly greater in the Alberta/Saskatchewan border area than in the Grasslands area ($z = 2.1$; $n_1 = 37$, $n_2 = 19$; $p < 0.05$).

While these numbers reflect changes in previously sampled Canadian townships, trapping success also differs between regions in townships that were surveyed for the first time during the 2000-2001 census. In the Alberta/Saskatchewan border region, 16 new townships were surveyed of which 8 (50%) had captures for a total of 22 foxes. Comparatively, of 11 new townships surveyed in Grasslands, only one (9%) had a swift fox capture. In Montana, the 66 newly surveyed townships had 21 (31.8%) with swift foxes, totalling 38 individuals.

Area differences over time are also apparent when examining trapping success/trapnights of effort. In 1996-1997, approximately three times as many trapnights were required for each new capture in the border area compared to the current census (Table 3). The success per effort ratio in the Grasslands National Park subpopulation on the other hand has only slightly improved. Currently, capture success is approximately 3 times higher in the border area than in Montana, but capture success in Montana is slightly higher than in the Grasslands population (Table 3).

The difference in captures between years and between areas was not due to a difference in swift fox trapability. Recapture rates, which are an indicator of trapability (Moehrenschlager and Moehrenschlager 1999), were similar for each of the study areas between years (Table 3).

The 1996-1997 trapability correction factor based on the home ranges and catchability of radio-tracked swift foxes (Moehrenschlager 2000), was applied when estimating the swift fox population (Cotterill 1997). This is reasonable due to the similarity in recapture likelihoods for the Canadian areas over time (Table 3). Estimated fox densities ranged from a low of 2.4 foxes/100 km^2 in the Grasslands area to a high of 9.2 foxes/100 km^2 in the Canadian border population (Table 4). Respective subpopulation estimates were 560 for the Alberta/Saskatchewan border area population, 96 for the Grasslands area, and 221 for Montana. The total, preliminary population estimate using this technique is estimated at 877 individuals.

Table 3. Comparative survey effort, capture success, and proportion of foxes that were recaptured at least once in the Alberta/Saskatchewan border subpopulation, the Grasslands National Park subpopulation, and Montana in 1996-1997 and 2000-2001.

Area	Number of Townships Surveyed	# of Foxes Caught	% of Foxes Recaptured	# of Trapnights / New Capture
AB/Sask. 1996-1997	39	24	33	29.5
Grasslands 1996-1997	19	8	25	41.3
Total 1996-1997	58	32	31	32.4
AB/Sask. 2000-2001	55	97	33	10.0
Grasslands 2001-2002	30	14	29	38.6
Montana 2001-2002	66	38	32	31.3
Total 2000-2001	151	149	31	18.1

Table 4. Survey effort, captures, estimated densities, and estimated population sizes for the Alberta/Saskatchewan border, Grasslands, Montana, and the total survey area.

Region	Region Townships	Region Area (km^2)	Townships Surveyed	Total Area Sampled (km^2)[1]	Foxes Caught in Sample	Estimated Fox Density[2] (foxes/100km^2)	Estimated Population Size
Border	65	5990.4	53*	3690.5	95*	9.3	560.1
Grasslands	43	3962.9	30	2013.0	14	2.4	96.4
Montana	80	7372.8	66	4428.6	38	3.0	221.4
Total	188	17326.1	149*	10132.1	147*	5.1	877.9

[1] Area sampled in region = (Area sampled per trapline * # of surveyed townships); (Area sampled per trapline = 67.1 km^2)

[2] Estimated Fox Density=[(# Foxes Caught in Sample * Correction Factor)/Area Sampled in Region] * 100 (Correction Factor = 3.5)

[3] Estimated Population Size = (Total Area of Swift Fox Range * Estimated Density)

* Two townships with a total of 2 fox captures were excluded in the border area because these areas were only trapped for 0.5 nights each.

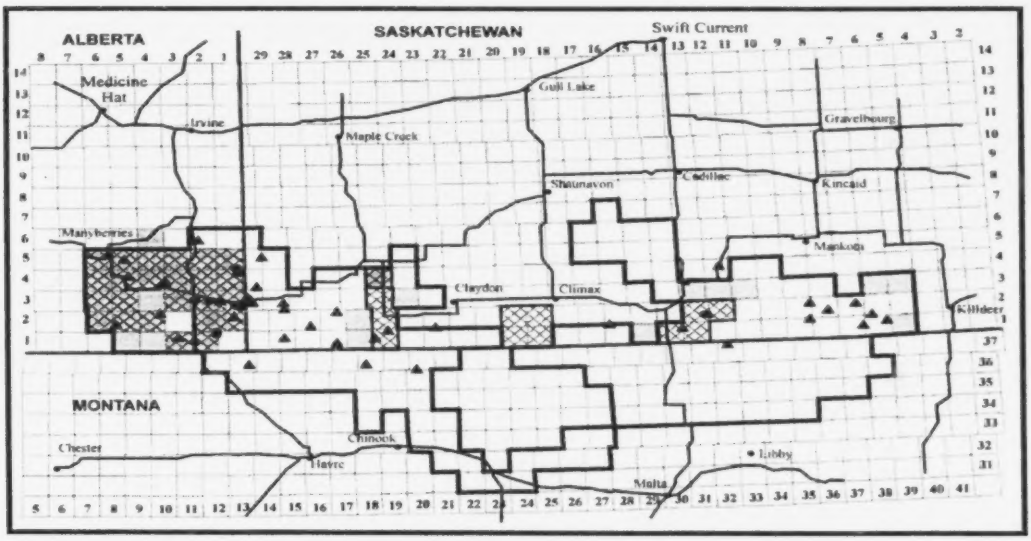
3.4 Population Distribution and Connectivity

The known swift fox distribution in Canada and Montana has significantly increased, in part because of a greater survey area and also because of a greater occurrence of swift foxes in re-surveyed regions. In the 1996-1997 census, swift foxes were trapped in 14 townships and additional sign was found in four townships to yield a known distribution of 18 townships in the Alberta / Saskatchewan border area. Comparatively, swift foxes were trapped in 32 and otherwise located in six border area townships for a total known distribution of 38 townships in 2000-2001. In the Grasslands National Park region, swift

foxes were trapped in six and otherwise found in one township, yielding a 1996-1997 known census distribution of seven townships; in 2000-2001, foxes were trapped in nine and additionally found in four townships for a total known range of 13 townships. During the current census, swift foxes were also trapped in 21 and otherwise found in four Montana townships.

In the Alberta/Saskatchewan border subpopulation, all trapped and sighted swift foxes were within 2 townships of another swift fox location (Map 3, Map 6). In the Grasslands National Park region, there is an apparent split between the eastern and western areas of the population as two clusters of swift foxes are separated by three empty townships (Map 4). This split might be exaggerated since no trapping, sign-tracking, or spot-lighting surveys were conducted in township 1, range 11 and township 1, range 12 (Map 4, Map 6). Nevertheless, this apparent gap continues into Montana, where no foxes are found in ranges 33, 34, or 35 (Map 5, Map 6). However, the incidental sighting of a swift fox in township 37, range 32 just south of the Canadian border (Map 6), reduces the apparent connectivity gap of the Canadian side to two townships.

The surveyed Montana population is artificially split in two because the pre-defined survey area had a gap in the center, and the random selection of townships within this zone excluded the southern, connecting region of this area (Map 1). In the western portion of the Montana survey area, all swift fox sightings or captures were within one township of each other and this block of swift fox presence is well connected to the Alberta/Saskatchewan border population.



Map 6
Sign-tracking, spotlighting and incidental sighting locations of swift foxes in 2000-2001.

Legend

- Suspected range
- Sign-tracking
- Sign-spotlighting
- Swift fox sighting during sign-surveying
- Incidental swift fox sighting

4.0 DISCUSSION

The primary focus of this international swift fox census was to estimate changes in the distribution and abundance of swift foxes within Canada since 1996-1997 and to estimate these parameters for adjacent areas in northern Montana. Over a study area that spanned 17 326 km^2, 149 swift foxes were captured from November 4, 2000 until February 15, 2001 and additional swift fox sightings or snow-tracking sign were documented.

The fact that 98.6% of captured foxes were unmarked suggests that swift foxes are reproducing successfully in the wild and that the population primarily consists of wild-born individuals. This proportion of wild-born foxes is higher than that previously recorded in other Canadian catch-and-release studies (Brechtel et al. 1993, Mamo 1994, Cotterill 1997, Moehrenschlager and Moehrenschlager 1999, Moehrenschlager 2000). This likely results from two factors: 1) the fact that the last swift fox releases in the Alberta/Saskatchewan border were conducted in 1996 and in Grasslands National Park in 1997 and; 2) the population is persisting and expanding through the recruitment of wild young instead of released foxes.

In resurveying Canadian townships that were originally sampled in 1996-1997, there was a statistically significant increase in capture rates while fox trapability was similar. Overall the population appears to have tripled in these areas over four years. This increase is primarily attributable to a surge in swift fox numbers in the Alberta/Saskatchewan border area. Perhaps the increase in the border population would not be surprising if 1996 had been a poor year, but daily radio-tracking from January 1995 until October 1997 and survival monitoring until February 1998, revealed that swift fox survival was higher in 1996 than 1995 and 1997 respectively (Moehrenschlager 2000). Hence, the increase in swift fox numbers documented during this census is already relative to a period of swift fox abundance.

The Grasslands National Park population showed smaller population increases in replicated areas and lower trapping success in newly surveyed areas than the Alberta/Saskatchewan border population. This explains why the marginal increase in swift fox captures on replicated Grasslands townships did not result in a significantly larger population estimate than that of the previous census. In contrast, capture increases in replicated Alberta/Saskatchewan border townships were complemented by high capture successes in newly surveyed areas. The fact that the Grasslands National Park subpopulation has had smaller increases than the border subpopulation is especially unexpected since over 50 captive-bred swift foxes were released into the Grasslands area in 1997, whereas no releases were made in the border region. The lower numbers of swift foxes in the Grasslands National Park area seems to suggest one of or a combination of three occurrences since the last census: 1) higher mortality than in the border area; 2) lower reproduction than in the border area; or 3) higher net dispersal from the region than in the border area.

The shift towards a female-biased sex ratio in 2000-2001 from a male-biased ratio in 1996-1997, suggests a higher ratio of effective population size/total population size now than before. Although skewed, the current sex ratio is better balanced and, as such, more effective than that recorded previously for this primarily monogamous species. However, swift foxes appear to occasionally be polygynous (Covell 1992; Olson et al. 1997; Moehrenschlager 2000) which may favour slightly female-biased populations. Hence, the increase in population size is also complemented by a per capita increase in reproductive potential.

Swift foxes in the Alberta/Saskatchewan border area, Grasslands National Park region, and Montana are closely connected. The largest gaps in the distribution span three townships, which is within the maximum dispersal distance of 34.3 km recorded for naturally dispersing Canadian swift foxes (Moehrenschlager 2000). Even so, the gaps in the distribution are likely exaggerated because of limited surveys. Future presence/absence assessments should concentrate on apparent gaps between the eastern and western regions of the Grasslands National Park area and adjacent regions in Montana, between the Canadian border and Grasslands National Park populations, and between the eastern and western Montana survey area regions where no trapping was conducted. The implications of a loosely connected but continuous population are numerous. The population should be less prone to genetic drift in isolated fragments, but the susceptibility to extinction at the hands of disease will now be greater for the population as a whole. The primary factor driving small populations of canids to extinction is disease, as recent outbreaks of canine distemper or rabies have shown in African wild dogs, Ethiopian wolves, Blanford's foxes, and Channel island grey foxes. During this 2000-2001 census, the study of wildlife disease in Canadian swift foxes was initiated and laboratory testing of collected blood samples will commence shortly.

Overall the Canadian swift fox population has increased in abundance and in its known distribution. The previous perceptions that the Canadian population consists of two subpopulations and that swift foxes may only be found in scattered pockets in Montana, no longer hold. Zimmerman's (1998) results combined with the findings from this census, show that the Montana population in the survey area is well established, consists almost exclusively of wild-born individuals, and is widespread. Moreover, the extent of the Canadian swift fox population reaches beyond the census area since occasional sightings have been documented in areas such as Suffield Alberta, north of Swift Current in Saskatchewan, and a single case in Manitoba. Moreover, the present Montana swift fox population, which originally drew its founders from Canadian releases, appears to be expanding as well. Recent surveys in Montana have shown a significant expansion as far west as the Sweetgrass Hills (Giddings, pers. comm.) and a southward reach into the Fort Belknap Indian Reserve (Stoneberg, pers. comm.). Indeed, the Montana population appears regionally well established, and it had higher capture success rates during this census than the Canadian Grasslands National Park population where releases were conducted for 14 years.

One crucial finding is that the Canadian swift fox population has substantially increased over a four-year span without supplementation from swift fox releases. Consequently,

swift fox releases are not necessary for the Canada/Montana swift fox population to increase in abundance or distribution, although such population supplementation may help to reduce the inbreeding effective population size (Ryman et al. 1995) and aid population subsistence over time.

While the population has clearly increased in abundance and distribution, the factors driving the increase are not understood. It is safe to say, however, that an absence of such favourable conditions and/or the occurrence of stochastic events could cause future population crashes. For example, if high prey abundance, favourable winter conditions, or low predator numbers allowed for strong population growth, then low prey densities, harsh winter conditions and high predator numbers would cause a decrease in population size. The magnitude of future increases or decreases will depend on the additive effects of such parameters and the impact of stochastic factors such as disease or drought. Because of high capture densities in January 1995 and subsequently high mortality rates in the spring and summer of that year (Moehrenschlager 2000), it is the opinion of the authors, that the high densities in the border population are beyond the carrying capacity of the area and we expect increased mortalities and decreased per capita reproduction in these core zones in 2001. Equally, however, these increased densities will likely drive increased dispersal and colonization along the edges of the swift fox distribution.

4.1 Recommendations

This international swift fox census has shown that the distribution and abundance of swift foxes has dramatically increased in Canada since 1996-1997. Moreover, swift foxes are clearly present in adjacent areas of northern Montana. This suggests that a genetically connected Canadian/Montana swift fox population has been established which now consists almost exclusively of foxes that have been born in these regions in the wild.

While these results are an encouraging sign that swift foxes may one day be forever returned to Alberta, Saskatchewan and Montana after decades of extirpation, one cannot assume that a minimum viable population size has been established at this point. A minimum population size of 500 is thought to maintain sufficient genetic variability in quantitative characters (Franklin 1980, Reed and Bryant 2000). However, this number has also been debated extensively. While Franklin and Frankham (1998) believe an effective population size of 500–1000 is generally appropriate, Lynch and Lande (1998) maintain that 1000–5000 individuals should be considered a minimum.

To ensure the protection and growth of the swift fox population, the authors believe that the following actions should be taken:

I. Continue to monitor the population to assess future growth or declines in abundance and distribution.

II. Develop rigorous education programs with the aid of local school teachers, farmers, and ranchers to increase swift fox awareness among children and adults in the very communities where swift foxes reside. The majority of

the swift fox distribution that was determined during this census lies in unprotected habitat. Consequently, the goodwill and continued support of local people is absolutely crucial towards the long-term survival of this species. This means that conservation planning for swift foxes must integrate the opinions and needs of local human communities.

III. Devise a habitat model that will define crucial habitat parameters for swift foxes in this population and subsequently allow for the protection of critical swift fox areas. Outside parks, the primary form of environmental protection should be landowner stewardship incentives. A rigorous habitat model will also delineate potential areas for future swift fox establishment.

IV. Reduce human-caused mortalities of swift foxes. Road-kills, accidental trapping, and poisoning of swift foxes are factors that can be more easily controlled than environmental conditions that naturally impact the population. Solutions to these problems should be devised with the involvement of local people.

V. Determine gene flow throughout the population to determine if isolated fragments exist that might be prone to inbreeding depression over time. In addition, conduct presence/absence surveys in areas where gaps were apparent in the swift fox distribution during this census.

VI. Determine age-specific exposure of swift foxes to canine diseases and the likelihood of disease contraction from sympatric canids.

VII. Integrate existing demographic data into a population viability model to determine time frame-specific likelihoods of population perseverance, identify primary threats that could drive the population to extinction, and establish swift fox-specific estimates of minimum viable population size.

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